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ENVIRONMENTAL RESTORATION PROJECT

A Department of Energy
Environmental Cleanup Program

Environmental Restoration Project
Quality Procedure

for:

Preparation of Design Calculations

Los Alamos
NATIONAL LABORATORY
Los Alamos NM 87545

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Preparation of Design Calculations

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Preparation of Design Calculations

1.0 PURPOSE

This quality procedure (QP) states the responsibilities and describes the process for performing and documenting design calculations either in support of specifications and drawings or as part of the overall design process on the ER Project.

2.0 SCOPE

2.1 All **ER Project personnel** shall implement this mandatory QP when performing and documenting design calculations for the ER Project.

2.2 **Subcontractors** performing work under the ER Project's quality program shall follow this QP when performing and documenting design calculations for the ER Project.

Or

2.3 **Subcontractors** may use subcontractor's procedure(s) as long as the substitute meets the requirements prescribed by the ER Project Quality Management Plan and approved by the ER Project's Quality Program Project Leader (QPPL) before the commencement of designated activities.

3.0 TRAINING

3.1 **ER Project personnel** shall train to and use the current version of this QP; contact the author if the QP text is unclear.

3.2 **ER Project personnel** using this QP shall document training in accordance with LANL-ER-QP-2.2, Personnel Orientation and Training; the training database is located at http://erinternal.lanl.gov/Training/login.asp.

3.3 The responsible **supervisor** shall monitor the proper implementation of this procedure and ensure that the appropriate personnel complete all applicable training assignments.

4.0 DEFINITIONS

4.1 *Assumption* — A design input that does not have direct reference to a controlled design document and is assigned a value for the purpose of preparing a calculation. The addend value shall represent a reasonable approximation of the actual value, based on sound engineering practice.

4.2 *Design Calculations* — Design media, which substantiates the design chosen, and which provides sufficient detail to establish that the design meets applicable functional requirements.

4.3 *Conceptual Design* — A pre-Title I activity that incorporates conceptual design estimates, conceptual design plan, conceptual project schedule, conceptual design report, and a constructability review.

4.4 *Definitive Design* — Design documents and processes defined in Title II Design (e.g., drawings, specifications, bidding documents, cost estimates, and coordination with all parties that might affect the project; development of firm construction and procurement schedules; and assistance in analyzing proposals or bids.

4.5 *Design* — The set of approved plans, criteria, procedures, specifications, and drawings governing design activities on the project. This includes construction contracts, contractor purchase orders, and industry codes and standards invoked by the design.

4.6 *Design Agent* — The organization assigned the responsibility for formulation of the design in accordance with established plans and procedures. Normally this is an architect/engineer or a construction contractor.

4.7 *Design Basis* — Information that identifies the specific functions to be performed by a structure, system, or component of a facility, and the specific values or ranges of values chosen for controlling parameters as reference bounds for design. These values maybe be:

- Restraints derived from generally accepted “state-of-the-art” practices for achieving functional goals; or
- Requirements derived from analysis (based on calculations and/or experiments) of the effects of a postulated accident for which a structure, system, or component must meet its functional goals.

4.8 *Design Inputs* — Those criteria, parameters, design bases, regulatory requirements, contractual requirements, customer expectations or other design requirements upon which detailed final design is based and are found to be technically correct and complete. Design inputs may include design bases, health and safety considerations, expected life cycle, performance parameters, codes and standards requirements, reliability requirements, standard engineering data, general engineering knowledge, and specific sources of controlled data, as follows:

- Standard engineering data consists of commonly available engineering properties (e.g., structural steel shapes, common pipe dimensions, water properties etc.).

- General engineering knowledge consists of basic engineering fundamentals (e.g., Ohm's Law, structural beam moment calculation, and Bernoulli Equations).
- Specific sources of controlled data that include written and traceable input. This information includes other technical design calculations, drawings, codes, standards, specifications, safety analysis reports, as-built walkdown reports, technical papers, manufacturer's data, and other supporting information.

4.9 *Design Output* — Technically correct design documents that meet the end-user's requirements such as drawings and specifications, test and inspection plans, maintenance requirements, report and other documents which are used to define and support technical requirements of structures, systems components, and material used during fabrication and/or construction and computer programs. Design output documentation may include as-built drawings and shop drawings that verify actual configuration of design implementation.

4.10 *Design Process* — Processes that translate design input into design output documents that are technically correct and are compliant with the end-user's requirements. Design processes address aspects critical to the performance, safety, or reliability of the designed items (e.g., dose and risk assessments, procurement, manufacturing, assembling, construction, testing, inspection, maintenance, and decommissioning).

4.11 *Engineering Judgment* — The substitution of specific engineering expertise or experience for detailed numerical calculations, which are based on sound engineering principles. To be acceptable, at least one of the following attributes shall be documented in the calculation when engineering judgment is involved:

- Quantitative comparison of the current input data to a previous calculation that was analyzed in detail.
- Qualitative evaluation of the current input data based logical discussion, which reflects the general body of knowledge of the preparer and reviewer.
- Bounding calculations prepared which supplement the current calculation and clearly demonstrate specific numerical results that can be readily compared to pass/fail or greater than/less than benchmarks.

4.12 *Supervisor* — An individual assigned to the ER Project who is a group, focus, task, team, or project leader or a manager with the authority and responsibility to direct and authorize ER Project activities.

5.0 RESPONSIBLE PERSONNEL

The following personnel are responsible for activities identified in this procedure:

- Checker
- ER Project Personnel
- Design Agent
- Design Engineer
- Subcontractors
- Supervisor

6.0 REFERENCES

To implement properly this QP, ER Project personnel should become familiar with the contents of the following documents, located at http://erinternal.lanl.gov/home_links/Library_proc.shtml.

- ER Project Quality Management Plan
- LANL-ER-QP-2.2, Personnel Orientation and Training
- LANL-ER-QP-3.2, Lessons Learned
- LANL-ER-QP-4.4, Record Transmittal to the Records Processing Facility
- LANL-ER-QP-6.3, Design Reviews

7.0 PROCEDURE

7.1 Prepare Design Calculations

7.1.1 Except for computer printouts, the **Design Agent** shall ensure preparation of design calculations on standard calculation paper (see Attachment A).

7.1.2 The **Design Agent** shall also ensure the use a calculation cover sheet (see Attachment B) to identify each set of calculations.

7.1.3 The **Design Agent** shall prepare calculations that permit clear, readable photocopies, microfilm images, or scanned computer input.

7.1.4 The **Design Agent** shall use a #2 pencil, black ink, or laser printer when preparing calculations.

7.1.5 The **Design Agent** shall ensure attachments are of the necessary clarity to permit usable reproduction of images.

7.1.6 The **Design Agent** shall ensure calculations printed neatly by hand, or typed; and shall organize calculations to prevent crowded or congested presentation.

7.1.7 The **Design Agent** shall ensure the use of letters, numbers, or symbols more than one-eighth inch high.

7.2 Use Appropriate Format

The **Design Agent** shall ensure design calculations are prepared in accordance with the following format:

Cover Sheet (see Attachment B)

I. Purpose and Objective

II. Methodology and Acceptance Criteria

III. Assumptions

IV. Design Inputs

V. References

VI. Calculations

VII. Summary and Conclusions

7.3 Identify Purpose and Objective

The **Design Agent** shall ensure the documentation of calculations' purpose and objectives as follows:

- Enter a clear and concise statement of the problem and the objective of the calculation.
- Enter the calculation type (e.g., slope stability analysis, wind load) and the identification of the affected system, component, or structure to establish the necessary technical background.
- Enter the identification of an initiating document (e.g., Field Change number, Project I.D. number, study, safety evaluation). The identification will serve as a source of design input data and establish functional requirements.

7.4 Address Methodology and Acceptance Criteria

The **Design Agent** shall

- describe the method or analytical approach to the problem;
- use an outline of the steps with clearly identified and discussed rationale for any non-standard analytical methods;

- state the acceptance criteria clearly in order to evaluate the results of the calculation in the conclusion section; and
- ensure the acceptance criteria are consistent with all required codes, design criteria and safety analysis reports and the stated purpose of the calculation.

Note: If applicable, make intermediate checks against design criteria throughout the body of the calculation (by reference).

Note: The acceptance criteria serve as the final comparison of all governing documents in order to verify acceptability of the final product.

7.5 Provide Design Inputs

The **Design Agent** shall

- provide a detailed listing of all design inputs used in the execution of the calculation;
- ensure the design input is based on the latest controlled design document, where possible; and
- ensure all design input information is reliable and traceable (i.e., list source title, document number, revision, date etc.).

7.6 Identify Calculation Assumptions

The **Design Agent** shall

- clearly identify all assumptions and the basis for their use; and
- ensure assumptions that require verification prior to construction (e.g., exact wall thickness, soil characteristic, etc.) identified and an action plan to coordinate closure provided in the conclusion section.

7.7 Identify References

The **Design Agent** shall

- provide a numbered list of all reference material utilized to develop the calculation;
- where the references are not easily retrievable, appropriate sections of the reference materials should be attached as an appendix to the calculation;

Note: In the event that “Copy Right” laws protect reference material, the design agent should consider identifying the references only or may elect to contact formally the owner’s of the material to request permission to copy the material.

- photocopied pages from references should be uniquely identified as part of the calculation (e.g., paste tables on correctly completed calculation sheet blanks);
- for each reference include a revision number, page number, date, edition, author, copyright, controlled document number, or other unique identifying characteristics; and
- computer calculations shall identify the program name/number and version of the program (number and date).

7.8 Present Calculations

The **Design Agent** shall ensure computations presented as follows:

- Formulae conform to the format as presented in the reference document; any variation is specifically noted.
- All variables and constants clearly labeled with the appropriate engineering units.
- Where unit conversions are required, the conversion factors clearly identified.
- The number of significant digits is justified by the input data, assumptions, and design methodology.
- All formulae are cross-referenced to the source via a note such as: "ref. 1, 5-432" (reference 1, equation 5-432).
- When using engineering judgment, include sufficient documented supporting rationale in order to assist with review of the calculation.
- Documentation submitted that verifies the use and selection of computer programs to support computations.
- Program input specifically identified, documented, and explained in sufficient detail to support detailed review, and possibly permitting calculation repetition.
- Select program, options, and algorithms in conformance with the Methodology and Acceptance Criteria section.
- Program output clearly identified to permit detailed review of the adequacy of results and provide source identification of the input.

7.9 Document Summary and Conclusions

The **Design Agent** shall

- summarize the computation and provide a clear statement of the logical conclusions of the calculation;
- evaluate the results in relation to the problem statement and objective;

- ensure any limitations or special conditions imposed by this calculation to maintain valid results are highlighted by a clear statement in this section; and
- ensure any assumptions which require verification prior to construction are summarized in this section (reference to calculation is sufficient).

7.10 Verify Calculations Process

The **Design Agent** shall

- ensure calculations contain the mathematical computations required to respond to the stated purpose;
- ensure that methodology is consistent with the stated Methodology and Acceptance criteria section; and
- ensure all significant mathematical results are highlighted by underlining or drawing a box around the result to assist with identification.

7.11 Check Calculations

7.11.1 The **Design Agent** shall ensure individuals (checkers) not directly involved with the preparation of the calculations check calculations, but who are proficient in the type of calculation used.

7.11.2 The **Design Agent** shall ensure a qualified checker checks calculations prior to use in any follow-up documentation, purchase, or construction activity.

7.11.3 The **Design Agent** shall ensure calculations checked using a photocopy and color-coded markings (e.g., red for differences in the calculations, blue for concurrence and green for comment incorporation).

7.11.4 The **Design Agent** shall ensure that the Design Engineer and checker review the calculations and agree upon correctness.

7.11.5 After agreement, the **Design Engineer** and **checker** shall finalize the calculations with a signature and date.

7.11.6 If necessary for clarity, the **Design Engineer** and **checker** may prepare new original calculation sheets to ensure that the calculations are clear and legible.

7.11.7 The **Design Engineer** and **checker** shall ensure all changes to calculations made by drawing a single line through the original entry, initialing, and dating the new entry.

Note: Perform the same checking process described above on these changes.

7.11.8 The **Design Agent** shall maintain calculation-check copies in the work package records file.

7.11.9 The **checker** shall confirm that the following requirements were met, along with all critical site-specific or facility-specific considerations identified by the Task Leader:

- Calculations include a completed cover sheet and prepared on standard calculation paper.
- Applicable engineering memoranda requirements met.
- Input data, references, and assumptions are correct, clear, and properly recorded.
- Methodology is appropriate.
- Analytical methods, numerical accuracy, completeness, compliance with design criteria, codes, standards, safety commitments, and reasonableness of output are correctly used.
- Any engineering judgments made within the calculation are reasonable and supported.
- Computer calculations checked for appropriate selection of program, features, and options consistent with the design approach, and proper verification and validation.

7.12 Control Attachments to Calculations

The **Design Agent** shall

- ensure attachments to calculations contain a listing of all attached pages;
- ensure attachments are identified as part of the calculation; and
- ensure any computer output generated in support of the calculation is included along with the identification and revision of the computer program utilized to generate the resultant data.

7.13 Use Computer Programs, as Appropriate

7.13.1 The **Design Agent** shall ensure the performance of two quality control checks for each computer program used.

7.13.2 During the first check, the **Design Engineer,** when choosing a program, shall ensure that

- the program is valid, widely accepted in the public domain, and considered appropriate to the task being performed;
- the theories and methodologies used in the program are understood;

- the theories and methodologies are appropriate when applied to the problem;
- the program was tested for precision and accuracy including verification of published problems and data similar to those on the project; and
- verification is documented and maintained.

7.13.3 An experienced **Design Engineer** and/or **checker**, other than the individual using the program, shall perform and document independent spot checks to verify the reasonableness of the computer-produced results.

7.13.4 The **Design Engineer** and/or **checker** shall ensure that these checks confirm the following:

- The user understands how to apply the program methodology to the problem.
- The user correctly entered the input data and program control data without typographical errors or omissions.
- The program produces reasonable results when applied to a specific type of problem.

7.13.5 During the second check, generally known as a validation test, the **checker** shall identify in the calculations which program used.

Note: The computer program is a record of the computational process used, and the computer input and output data are the basis for the results.

7.13.6 The **Design Agent** shall ensure the attachment of the computer input and output data to all calculations and the filing of a copy of the computer programs with the applicable work package file.

7.13.7 The **Design Agent** shall ensure ER Project-owned programs and relevant input and output data are stored on magnetic tape, floppy, and/or hard disk.

7.13.8 The **Design Agent** shall ensure the filing of one copy of the tape, floppy, or disk with the work package file and a second copy archived in the ER Records Processing Facility.

7.13.9 For programs not owned by the ER Project, the **Design Agent** shall archive only the computer input, output data to a diskette or tape, or print, and file it with the applicable work package file.

8.0 LESSONS LEARNED

8.1 Before performing work, **ER Project personnel** should go to the U.S. Department of Energy, lessons-learned web page, located at http://www.tis.eh.doe.gov/ll/ll.html and/or the Los Alamos National Laboratory, lessons-learned web page, located at http://www.lanl.gov/projects/lessons_learned/, and search for applicable lessons.

8.2 During the performance of work, ER personnel, as appropriate, shall identify, document, and submit lessons learned, as appropriate, in accordance with LANL-ER-QP-3.2, Lessons Learned, located at http://erinternal.lanl.gov/home_links/Library_proc.shtml.

9.0 RECORDS

The **Design Agent** shall submit the following records (processed in accordance with LANL-ER-QP-4.4, Record Transmittal to the Records Processing Facility) to the Records Processing Facility.

- Completed calculations, including the cover sheet.
- Calculation reviews and approval documentation.
- Computer input and output data (e.g., hard copy, magnetic tape, diskette and/or hard disk)
- Associated correspondence (e.g., faxes, e-mails, documented telephone communications, memoranda, letters, etc.)

10.0 ATTACHMENTS

All forms associated with this procedure are located at http://erinternal.lanl.gov/Quality/user/forms.asp.

Attachment A: Calculation Sheet form (1 page)

Attachment B: Calculation Cover Sheet form (1 page)

Attachment C: Design Calculation Preparation Process Flow Diagram (2 pages)

Calculation Sheet	Calculation No.: _____		
Project Title:	Contract/Task Order No.	PRS No.	Sheet No. : of
Feature:	Prepared By:		Date:
Item:	Checked By:		Date:

Example
This form is available online via a link from the form title in Section 10.0.

Calculation Cover Sheet		Calculation No.: _____	
Contract No./Task Order:	**PRS No.:**	**Discipline:**	**No. of Sheets:**
Project Title:			
Purpose and Objective:			
Methodology and Acceptance Criteria:			
Assumptions:			
Design Inputs and References:			
Calculations:			
Summary and Conclusions:			

☐ **Preliminary Calculation** ☐ **Final Calculation** ☐ **Supersedes Calculation No.:**

Revision No.	Revision	Calculation By	Date	Checked By	Date

Example
This form is available online via a link from the form title in Section 10.0.

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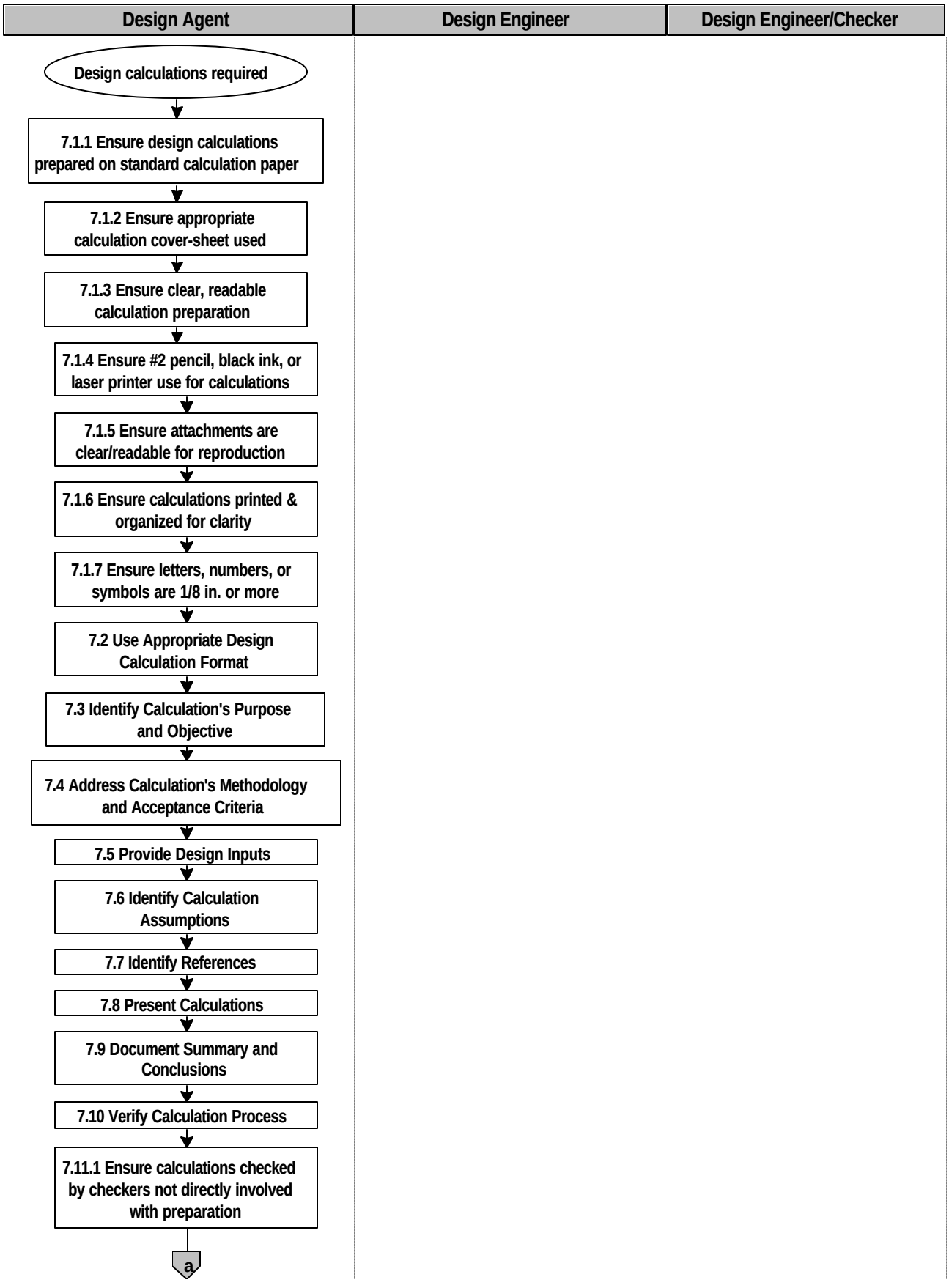
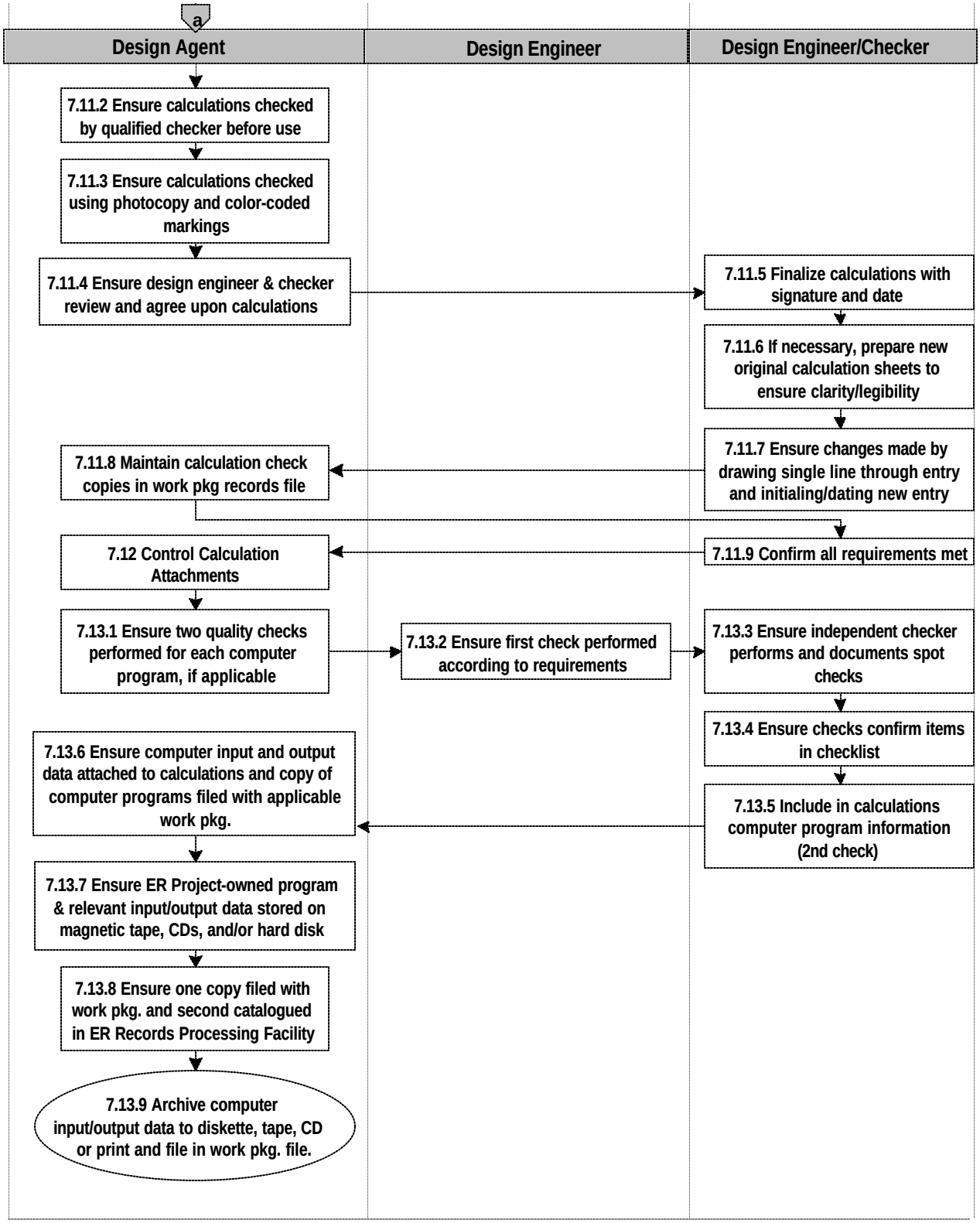
Los Alamos
Environmental Restoration

Design Calculation Preparation Process Flow Diagram



Design Calculation Preparation Process Flow Diagram (Cont.)